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**A Cross-cultural Study of Domesitc Luminous Environment
in the United Kingdom and Japan**

2007

MSc Built Environment: Light and Lighting

Junko Inomoto

13 SEP 2007

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A Cross-cultural Study of Domestic Luminous Environment
in the United Kingdom and Japan

14 September 2007

University College London
The Bartlett School of Graduate Studies
MSc Built Environment: Light and Lighting
Junko Inomoto

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1 INTRODUCTION

1.1 Background and Purpose of the Study

Today as the globalization in economics and cultural exchanges increase, architects and designers from various nationalities get to design buildings all over the world. Although there are local restrictions and constraints that may limit and shape of the built environment, easy-access to worldwide information via internet and telecommunication, as well as global distribution network of products makes it possible to replicate monotonous designs anywhere in the world. In a lot of urban cities, people now are surrounded by steel, glass and concrete, and are able to work day and night under stable lighting environment.

For centuries, before the invention of electric lighting, all built spaces were reliant on daylight and on the small flame of candles and oil lamps. Innumerable architectures evolved, with great varieties, at different places depending on their climate conditions, cultural backgrounds and local materials. As the quality of the natural light differs depending on place and time, architects developed many unique architectural details to reveal both the inside and outside of the three-dimensional structures. These architectural details with interplays of light and shadow can be still seen in many of the existing historic buildings. Over the past hundred years, however, the advent of electric lamps has dramatically changed the use of natural light as a building component. The worldwide introduction of the incandescent lamp in 1880s and fluorescent lamp in the mid-20th century led to an enormous change in lighting concepts for the built environments. It is possible to say that human civilisation has evolved dramatically around artificial lighting over the past hundred years.

At present, many of the same artificial light sources became ubiquitous light sources for illuminating interior spaces all day long. The light sources widely available tend to produce anonymous lit environments. In the extreme cases, such as in the 1980s, many deep plan offices were designed that were virtually daylight-free with centrally controlled artificial lighting and ventilation systems¹. The result of such built environments was the wasting of large amounts of energy and creating a negative impact on physiological conditions of the occupants, reducing performance and motivation. Today the trend is towards the utilization of daylight and its interaction with artificial lighting.

The purpose of this study is to rediscover the varieties and unique qualities of luminous environments that are preferred in different countries. It compares the luminous environments created with daylight and electric light for two different cultures, United Kingdom and Japan. Since the quality of daylight differs from

1 - DETAIL Practice 'Lighting Design' (Birkhauser, 2006)

place to place, traditionally their vernacular architecture developed different styles to incorporate the natural light into the built environment. In this paper it analyses whether these original ways of admitting daylight into the building have any links to the current use of artificial lightings in the two countries.

United Kingdom and Japan today are two developed countries with similar economic levels of activity, but with different climate, cultural tradition and use of materials for house building. On a daily basis there exists diversity in artificial lighting between the countries even though the same palette of light sources is available to both. There are several research papers that suggest the Japanese prefer higher illuminance and tolerate stronger glare sources in offices compared to Europeans². These facts can also be evidenced in their different recommendations for interior illuminance levels³.

Our experience of light is rooted in the place or places where we grew up. What we see and find in our visual environment is not only related to individual's physiological reaction, but also influenced by one's psychological aspects; personal experience, expectations and emotion. Thus the visual experience that one's attracted to, has a range of preferences that may be universal, cultural, or personal. Our experience of light is cumulative and very complex.

In recent years, the worldwide drive for energy conservation has urged the lighting industry to develop light sources such as LED or OLED with a good efficacy, as well as turning our attention to the greater use of daylight to illuminate the interior space. Also, with regard to the field of architectural lighting design, the aim became not only to fulfil the functional illuminance for visual tasks, but also to consider the quality and comfort of the lit environment including its energy efficiency. In order to present the above requirements of today's market, it is essential to identify the patterns of light which satisfies our physical and mental well-being.

A cross-cultural study contrasts the cultural characters of luminous environments that are preferred in different countries. It may also differentiate the unchangeable cultural elements from elements that can be changed. In this paper comparisons are made of the vernacular architectures and the current lighting environments of UK and Japan. As P. R. Boyce (2002) indicates, '... every lighting installation sends a "message" about the people who designed it, who bought it, who work under it, and about the place it is located. Observers interpret the "message" according to the context in which it occurs and their own culture and expectations.' At the time when international designers have

2 - Akashi et al. UGR and Subjective Appraisal of Discomfort Glare (JIEJ, 1994)

3 - Mills and Borg. Trends in recommended lighting levels: An international comparison (1999)

their vast opportunities to produce borderless works around the world, this study aims to reappraise the diverse qualities of luminous environment in different places and provide cross-cultural feedback for their design implementation.

1.2 Past Cross-cultural Researches

In the latest cross-cultural study, Küller et al. (2006) carried out an international study in the real work environment for different seasons in four countries at different latitudes (Argentina, Saudi Arabia, Sweden, and United Kingdom). A questionnaire consisting of seven or eight pages was used on a total of 988 persons (468 females and 520 males) aged 18 to 65 years, in order to examine the hypotheses that light and colour in the workspaces will influence the mood of people working there. The results indicate that in the countries situated to the far north of the equator a significant variation in psychological mood was found over the year that did not occur in the countries closer to the equator. The existence of an interaction between season and country was pointed out, which could be ascribed to variations in length of a day. When all four countries were considered together, it became evident that light and colour of the indoor work environment had an influence on the mood of persons working there. In addition, the illuminance as measured in objective terms showed no significant impact on mood at any time of the year.

Park (2001) conducted experimental research comparing Caucasian American and Korean subjects for the possible effects of light quality with colour temperature and colour rendering index (CRI) on lighting perceptions. The results of Park's study can be summarized by saying that the American subjects estimated all lighting conditions as arousing whilst the Koreans did not respond in the same way. Higher colour temperature of 5000K had more impact on the visual clarity than 3000K, while CRI was no different for all subjects. Americans perceived their skin tone as more attractive under 3000K, while Koreans perceived their skin tone better under 5000K.

In the research of Mills and Borg (1999), the recommended illuminances for different activities in offices for 19 countries show considerable variation. Although it should be noted that the data collected was not all from the same year. The trend in illuminance recommendations for virtually all countries increased in recommended illuminances for office work from the 1930s until the early 1970s, followed by either a stabilisation or a decline.

Wilhite et al. (1996) compared and contrasted the results of ethnographic investigations of household energy use in Fukuoka, Japan and Oslo, Norway. In their findings, they highlighted the opposing preferences in lighting of

living room. Whereas Norwegian used shaded floor and table fixtures with incandescent lamps for the living room, most Japanese used ceiling luminaires with fluorescent lamps. It pointed out that Japanese are more interested in visibility than in creating the mood with warm-coloured incandescent lamp.

1.3 Research Question

The cross-cultural studies cited above have focused on different themes related to lighting. In this study it is hypothesised that varieties in preferences and utilizations of artificial lighting in United Kingdom and Japan are related to their vernacular architectures how daylight was manipulated creating their traditional visual environments.

The present lighting environments in Japan are generally preferred to be brighter than United Kingdom. There seems to be a certain preferences and styles for the contemporary use of artificial lighting environment at different places. In this paper it is questioned whether these facts are the influenced by cultural and visual experience in traditional architecture which can still be experienced even today in the two countries.

This study, of vernacular architectures is limited to London and the southeast in the UK and Kyoto in Japan. The architectural styles are selected from typical town houses of Georgian architecture and Machiya of Edo period. Both of these styles evolved around 18th to mid-19th century before electric lighting was introduced in the late 19th century. A Machiya model was selected from Kyoto for this study, as Kyoto was a capital city of Japan in the Edo period, and these town houses spread throughout Japan from Kansai/Kyoto area.

The design of town houses in the UK and Japan is the result of urbanization around the 18th century and is generally represented by rows of houses on small plots. This study focuses on the vernacular architecture of urban dwelling, how their designs were elaborated to incorporate natural light in the tight space at earlier times.

2 BACKGROUNDS

Both the UK and Japan are island countries. The UK lies between the North Atlantic Ocean and the North Sea, it is located to the northwest of mainland Europe. The mainland lies between latitudes 49 degrees and 59 degrees north. Japan is situated in the Pacific Ocean to the east of the Asian continent. While the Pacific Ocean lies to the east, the Sea of Japan and the East China Sea separate Japan from the Asian continent. The Japanese archipelago lies

between the latitudes 20 degrees to 45 degrees north. The latitude of Kyoto is 35 degrees north which is about the same as Athens and Los Angeles, while London is 51.5 degrees north which is the same as Berlin and Vancouver.

From geographical, cultural and historical perspectives the UK and Japan have many differences as well as a number of similarities. In this section, differences in some of the important contexts are pointed out that are relevant to the origin and formation of vernacular architectures, and lighting environments of today.

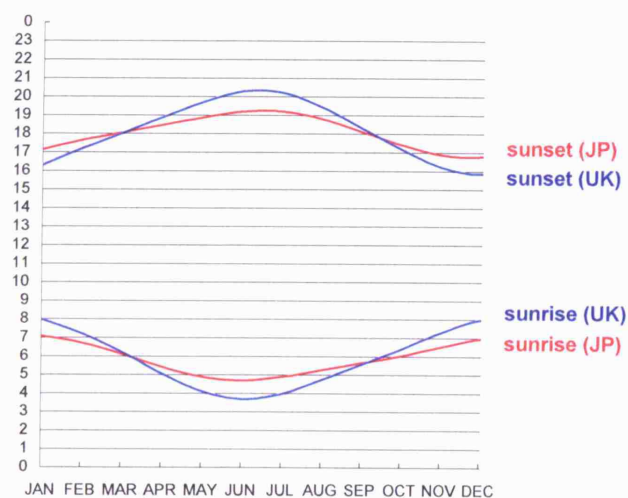
2.1 Climate

Although both countries lay predominantly in the temperate climate zones, their climatic features are quite different. UK has cool winters and warm summers, with overcast skies possible at any time of year. In the southern part of UK including London, the temperatures generally do not fall much lower than 0 degree in winter and do rise not much higher than 30 degrees in summer.

In Japan *Honshu* (the main island) generally has moderate winters and hot summers, however, the climate varies considerably from place to place with regards to topographical feature of Japanese land. The Pacific Ocean side of the *Honshu* including part of Kyoto enjoys generally clear skies during the winter with average temperature around 5 degrees, and has hot summer weather with many days when temperatures rise above 30 degrees centigrade.

Interestingly to note here in comparing the two countries is the variations in length of daylight from winter to summer. Whereas Japan has about five hours difference in the duration of the daylight from winter to summer, UK has about nine hours difference. Figure 2-1 shows the sunrise and sunset times of London and Kyoto throughout the year.

FIGURE 2-1
Durations of sunrise and sunset time throughout the year



2.2 Residential Architecture and Life Style

Traditionally, vernacular architectures of the UK and Japan show great contrasts in style. Whilst a lot of residential buildings in UK were built with brick or stone, Japanese houses are associated with wooden construction. Since overcast skies predominate in the UK, light is often dull and grey. Thus having no eave, plane building façade with clear glass apertures with or without curtains or blinds were used to admit natural light into the interior. Relatively tall in height, rectangular windows allowed more direct daylight to enter the rooms, creating relatively strong contrast of light and shadow for the luminous environment (Figure 2-2).

FIGURE 2-2
Georgian window (left) and
daylit drawing room (right)

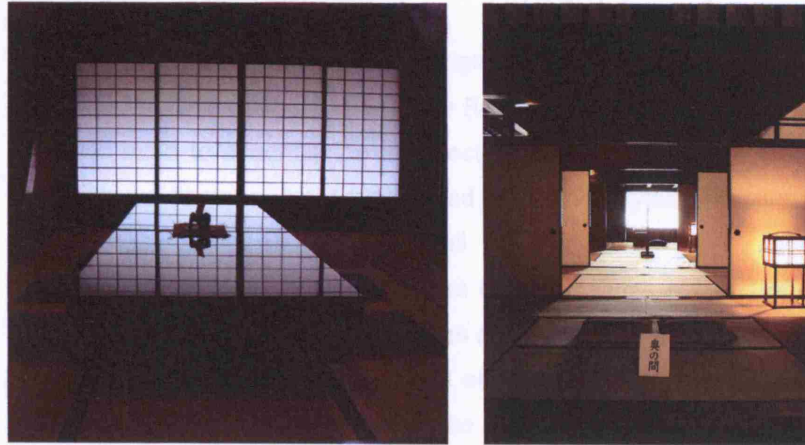


Compared to the brick or stone construction, building in wood has more flexibility in the arrangement of openings. Generally, traditional wooden houses in Japan had sets of removable panels facing the exterior and they could be opened up to have continuous space from inside to outside the house. The removable panels may be one of the following three kinds: *shoji* (translucent paper-covered panel that admits light), *fusuma* (opaque panel covered with decorative paper on both sides), or *mairado* (wooden panel).

Since summer in Japan is hot and humid and considered to be the most difficult season, Japanese house builders clearly modified their designs to provide comfort for the summer. Direct sunlight was blocked off with a broad eave overhanging the house and also with a veranda reflecting the indirect light to ceiling. Overall, daylight entering the interior was controlled by the use of paper-covered sliding panels called *shoji* diffusing all the light, and producing a softer and more uniform lit environment (Figure 2-3).

Whereas many Georgian houses are still lived in England and Ireland, many Japanese Machiya town houses have been torn down to make room for the post-war modernization and replaced with modern housing. Today, houses in Japan would commonly have both Japanese-style and Western-style rooms. Despite the changes that modernization has brought to the styles of houses, the

FIGURE 2-3
Shoji screen (left) and interior
with sets of sliding panels
(right)



traditional Japanese style can often be found in a room with woven rush mats called *tatami*.

For Japan, which is frequently hit by earthquakes, the skeleton wood frame was adopted for earthquake-resistant construction. Although the house was often destroyed by fires, timber was the most abundant raw building material in Japan and it made quick reconstruction possible. This shows an interesting contrast with the building history of the UK where wood was limited in its use in cities after the Great Fire of 1666. Brick and stone became the main construction materials.

Rooms in traditional Japanese structures were mostly multipurpose and were divided with sliding partitions when necessary. For Japanese it is the custom to remove shoes before entering the house and to sit on the floor in a room, which held only a few items of furniture. Chairs were not used, people sat on cushion mats with a low table, and were sleeping on the futon mats. All of these items of furniture were put away in the built in closet during the night or day when they were not use.

Whereas traditional Japanese rooms were quite open with the use of removable partitions and had less furniture, rooms in the UK were defined by the solid walls and usually had many items of furniture. Each room was designated to be living room, dining room or bedroom, and the timber floor could be covered with rugs/carpets and have cabinets, couches, chairs and tables, or beds, according to its use.

Back in the 18th century, the residents of Georgian town houses were considered to be middle class or upper middle class, having servants living in the basement or attic, whilst Machiya was typically mixed commercial and residential space where lower to middle classed merchants and artisans lived and worked.

2.2.1 Georgian House

Georgian architecture developed in England out of the Classical Revival which dominated Europe during and after the Renaissance and age of Enlightenment. Typically used to describe the architecture in the period from 1720 to 1840, Georgian buildings can be distinguished from other styles of architecture by its proportion, symmetry and order of detail.

Typically, English Georgian architecture used the Dutch practice of contrasting reddish brick with white sash window as an accent. The pattern of windows was standardized, as was most decorative elements. On the ground floor windows were kept short for stability of the house structure, and first floor windows were tall and the most expansive, second floor became shorter, and on top floor almost square. This regularity of house facades along streets was an attractive feature of Georgian town planning (Figure 2-4).

FIGURE 2-4
Facades of Georgian town
house

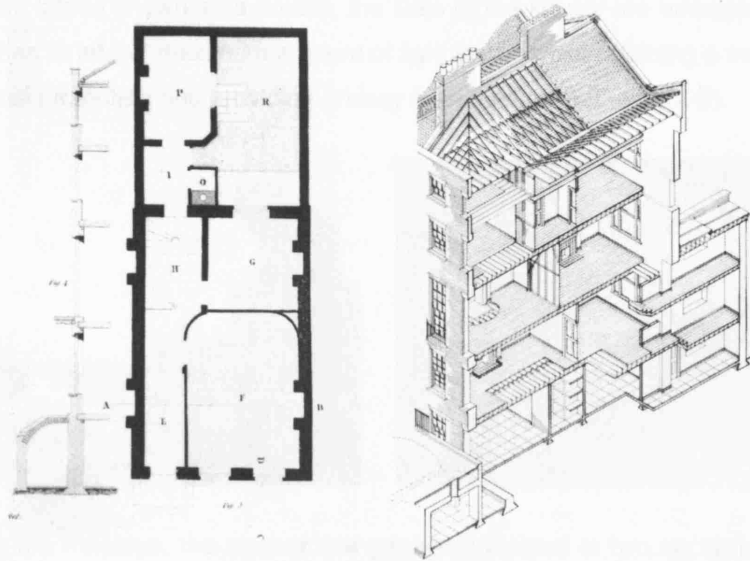


The 18th century was a time of great urban growth, thus in the Georgian period many town houses were built. The most common Georgian town house designs were of three or four storeys, with an attic. The plan was generally rectangular behind a narrow frontage, with two rooms per floor. By the early eighteenth century, a 'standard' plan had developed whereby the staircase was placed to the rear along a party wall, beyond an entrance hallway, allowing the hallway to be directly lit by fan lights over entrance door⁴ (Figure 2-5).

Inside the town house, the ground floor usually contained the dining room and a sitting room which may also have been reserved for business use, while the best drawing room was increasingly to be found on the first floor at the front.

4 - English Heritage. Town Houses (Domestic Buildings 2) Available from:
<<http://www.english-heritage.org.uk>>

FIGURE 2-5
Section/plan and perspective
of Georgian town house



However, there were many variants depending on the uses given to the principal floors. For instance whether there was a basement or not, or whether the building was intended as a house, or to be part house part shop or workshop.

Much of the standardisation of Georgian house design can be traced back to the building legislation introduced in London after the Great Fire in 1666. Over the years these restrictions were gradually imposed on things such as the height of rooms, structural thickness of party and external walls, and the size of timbers for floors and roofs⁵. While brick was the primary building material, the interior was finished with panelled walls, ornamental plaster ceilings, carved fireplaces, and timber flooring.

2.2.2 Machiya

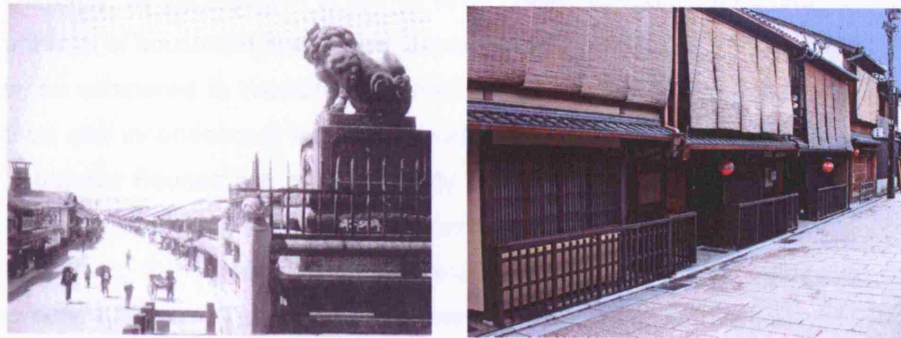
Machiya is a traditional wooden town house built throughout Japan, which is typified in the historical capital of Kyoto. Typically Machiya was mixed commercial and residential space, where merchants and artisans lived and worked, provided with a store space in front, family living space in the middle, and workshops/storehouses in the rear. Machiya originated as early as the Heian period (794-1185) and continued to develop through to the Edo period (1603-1868) and even into the Meiji period (1868-1912).

The typical Kyoto Machiya is a long wooden structure with narrow street frontage, often containing one or more courtyard gardens to admit more light into the interior. Machiya plots were generally only 5.4 to 6 meters wide but about 20 meters deep. Generally built as one or two storeys, from the outside the machiya have a similar appearance. The ground floor windows have a

5 - Hamilton, J. Weymouth's Georgian Seafront Architecture. Available from:
<<http://www.users.globalnet.co.uk/~wykedh/webgeorge/index.htm>>

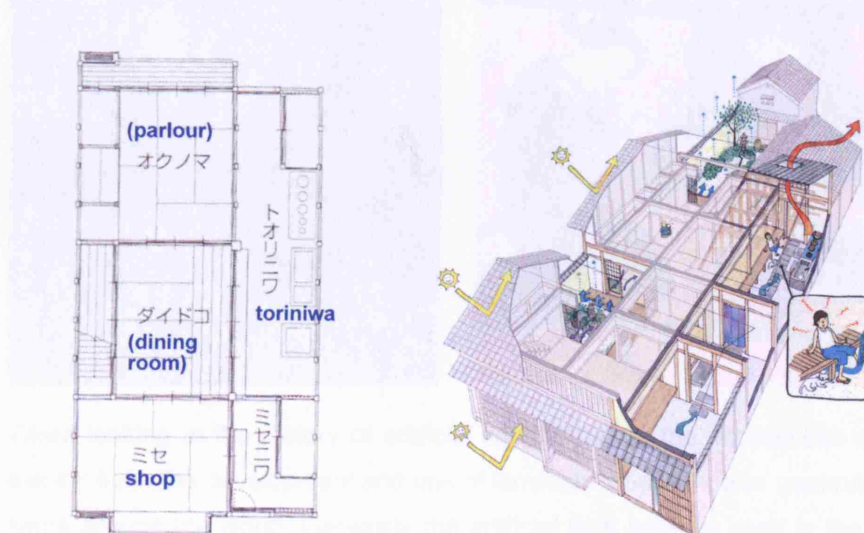
wooden lattice known as a *koushi*, the slats of the *koushi* are arranged in such a way as to let the maximum amount of light inside while retaining a measure of physical protection and providing privacy from the street (Figure 2-6).

FIGURE 2-6
Kyoto Machiyas in Meiji pe-
riod (left) and facades now
(right)



Inside the machiya, the spaces are generally divided in two sections: service and circulation space called *toriniwa* with an earthen or stone floor; the shop area closest to the street and living spaces towards the rear with a raised floor (Figure 2-7). The *toriniwa* extends from the front to the back of the house, and three rooms were placed adjacent to it. As in most traditional Japanese structures, the rooms are multipurpose and are partitioned with sliding panels called *fusuma* (paper-covered opaque panel) or *shoji* (wooden-framed panel with rice paper that admits light) that can be removed to open up the entire space even extending the view to the garden. The other wall surfaces of the inside rooms are created from a mixture of sand, straw and clay laid over a bamboo lattice, which may be similar to the lathe and plaster wall in the UK.

FIGURE 2-7
Ground floor plan (left) and
perspective of Machiya (right)



The second storey of a Machiya was where the family would sleep and was also used to store items for the shop. Inside a machiya the ceiling was usually finished in wood: either having an exposed ceiling which consists of several large beams that support the floor or the room above, or these beams were covered by wooden panels to create flat ceilings. From the late 17th century onward, the floors of most rooms were covered with *tatami*, woven rush

rectangular mats of a standard size.

2.3 Artificial Lighting

Currently, as the research of Wilhite et al. (1996) suggest in their cross-cultural analysis of household energy use, Japanese residential lighting is much brighter when compared to Western countries. Whereas Western countries use more than one incandescent lamp and more point sources for their living spaces, Japanese houses are predominantly lit with a ceiling mounted fluorescent luminaire producing a uniformly lit environment. These comes in many shapes and sizes, the fluorescent lamp typically used in Japanese residences is a circular tube type. The lamps are generally covered with diffusing acrylic, glass, or traditional paper, the luminaire is design as illuminated surfaces. By the turn of 21st century, Japan led the world in the percentage of household using fluorescent lamps⁶.

It is said that the colour temperature preferred in Japanese residences is about 4000K to 6700K, whereas in Western countries it would be from 2800K to 3000K that is represented by the colour temperature of incandescent lamp⁷.

FIGURE 2-8
Oil lamps used in the UK and
a lantern used in Japan

When looking at the history of artificial lighting before the introduction of the electric light, the development and use of lamplight after dark was generally the same around the world. Generally the artificial light sources used in the 18th century were oil lamps and candles, however, the different cultures controlled these light sources in different ways by protecting the flame and/or controlling the flow of air to the flame. In the UK this control of flame may be typified by the addition of a small glass chimney. In Japan the flame was often wrapped around

6 - Yamaya, T. Outline of Self-Ballasted Fluorescent Lamps: From the Past to Now, and to the Future (JIEJ, 2003)

7 - Yamaya, T. Cultures of the World, Countries and Home Lighting (JIEJ, 2001)

with a paper shielding device (Figure 2-8). These control devices for lamp mirrors the opening in vernacular house design for the manipulation of daylight.

One result of the different living styles can be seen in the location of lamps. In the UK lamps were often placed higher than the task level, being hung from the ceiling, mounted on the wall, or used as table or floor lamps. In Japan a lantern was generally placed on the floor in the corner of the room illuminating the lower part of the room only.

The way in which Japanese used to place their lanterns on the floor and how they now prefer the fluorescent ceiling luminaire shows a dramatic change in the use of artificial lighting. This may be linked to westernization of the country in the Meiji period and after the World War II⁸. The restrictions in the use of artificial light during the war may have resulted in the people longing for more brightness. So that after the war the new bright light, the fluorescent lamp, became more like an icon for peace and rich modern life.

3 METHODOLOGY

3.1 Study Method

The analysis of interior daylight environment in UK and Japan is conducted by producing three-dimensional computer models of two buildings that represents traditional town house in London and Kyoto. In this study the computer simulation was used as it is hard to replicate a study in different countries with varying climate conditions, and it makes comparison in absolute figures easier. The program AGI32 (version 1.95) was used to model the reflectance of surface materials used in vernacular buildings, allowing a simulation of the spatial lighting effects including inter-reflections. Three-dimensional computer models of Georgian town house and Machiya were generated with AutoCAD and then imported to AGI32 software for lighting simulations.

AGI32 software employs the Radiosity techniques which can calculate the inter-reflection of light within an environment. However, the limitation of this software package is that it tends to generalise each surface, treating it as a perfect diffusing reflective and transmissive surfaces⁹. This results in reducing all material types down into one common characteristic, but doing so allows for relatively fast calculation and effective visualisation of the lit environment. Within the above limitation, computer renderings and luminance distribution of the daylit interior are generated, and these results are used to analyse and compare to the present artificial lighting environment in the Chapter 6.

8 - Inui, M. Rousoku to keikoutou (Candle and Fluorescent lamp). (Shodensya, 2006) p79

9 - Jackson, C. Visualising lighting effects. (The Bartlett, 2006)

Both computer models of Georgian house and Machiya were generated by referring to the drawings shown in several books. Two plans of Georgian and Machiya houses show similar dimensions of about 10 meter long by 4 meter wide for the rooms on the ground level excluding the hallway.

The daylight analysis for the two buildings was made for the following key rooms (Figure 3-1):

Georgian

1. Ground floor: front room
2. Ground floor: back room
3. First floor: drawing room

Machiya

1. Shop
2. Dining space
3. Parlour

Typically a Georgian town house was organized with two rooms, while Machiya had three rooms. The dimension of each of the rooms varies.

For the Georgian house, the two ground floor rooms and the front room on the first floor were simulated for different daylight conditions. In the past a lot of Georgian houses adopted the front room of the first floor as a drawing room. This implies that this room was the best environment for entertaining guests. For Machiya, rooms on the first floor were generally used for storage or sleeping, and the parlour and dining spaces were located behind the shop area on the ground level. Thus daylight simulations were conducted for three rooms (shop, dining, and parlour space) at the ground level for Machiya model, where people spent most time during the day. The importance of the first floor drawing room in a Georgian house and the ground floor parlour in Machiya to the occupants is reflected in the discussions in Chapter 6.

The generated computer models of Georgian house and Machiya was simulated under the overcast (type 1) and clear sky (type 13) defined in the CIE Standard General Skies (CIE, 2003) to examine the performance of the designed openings and characterise each room in different orientation and location. For the simulations under the overcast sky, exterior illuminance was set at 10,000 lux for calculation. Calculation points were laid at 0.5 meter grid on the floor plane for both Georgian and Machiya models to measure the daylight factors of each room.

FIGURE 3-1a
Ground floor and first floor
plan of Georgian house

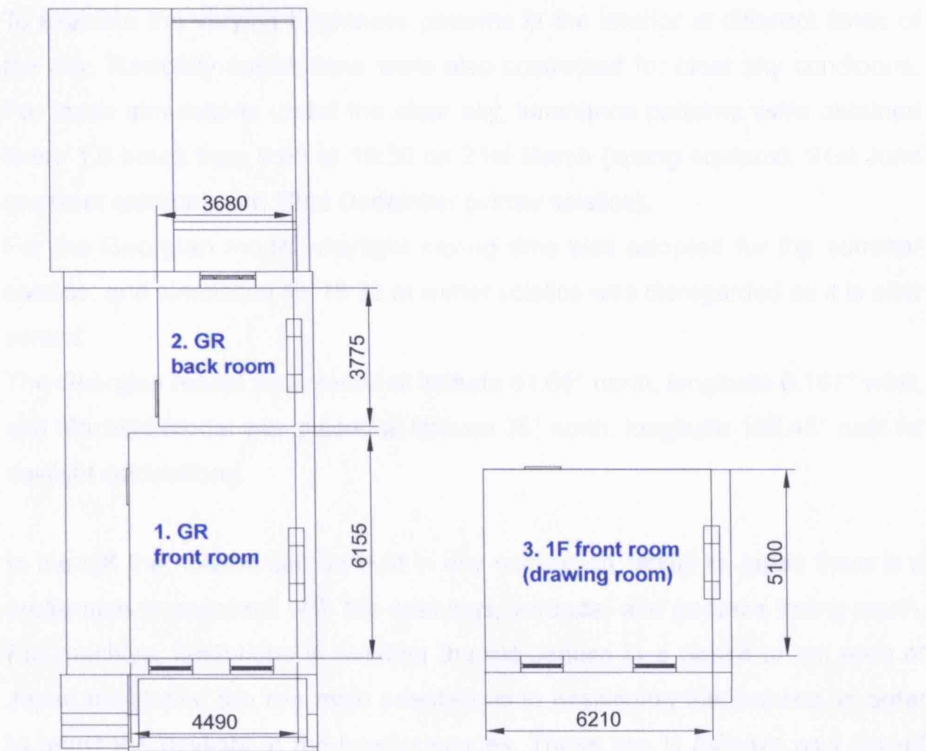
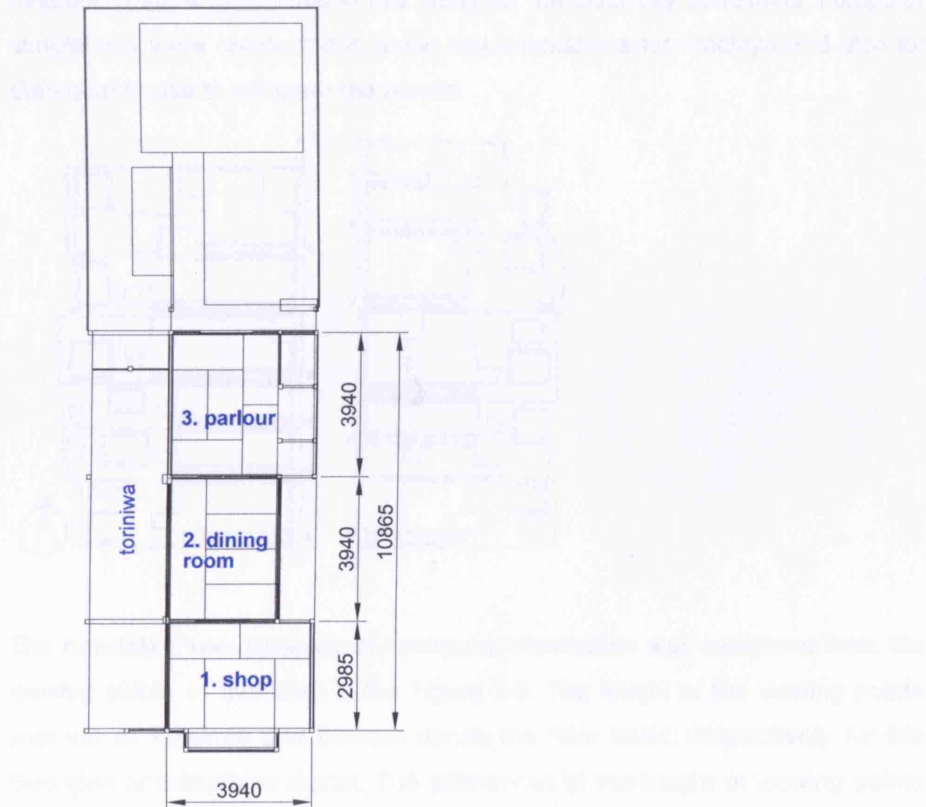


FIGURE 3-1b
Ground floor plan of Machiya



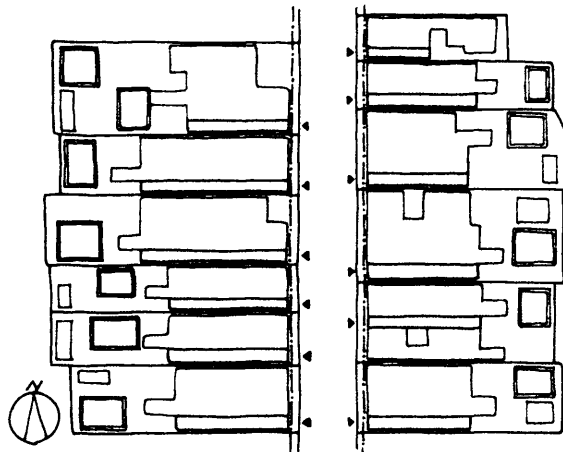
To examine the varying brightness patterns in the interior at different times of the day, Radiosity calculations were also conducted for clear sky conditions. For these simulations under the clear sky, luminance patterns were obtained every 1.5 hours from 9:00 to 16:30 on 21st March (spring equinox), 21st June (summer solstice), and 22nd December (winter solstice).

For the Georgian model, daylight saving time was adopted for the summer solstice, and simulation for 16:30 at winter solstice was disregarded as it is after sunset.

The Georgian model was placed at latitude 51.65° north, longitude 0.167° west, and Machiya model was placed at latitude 35° north, longitude 135.45° east for daylight calculations.

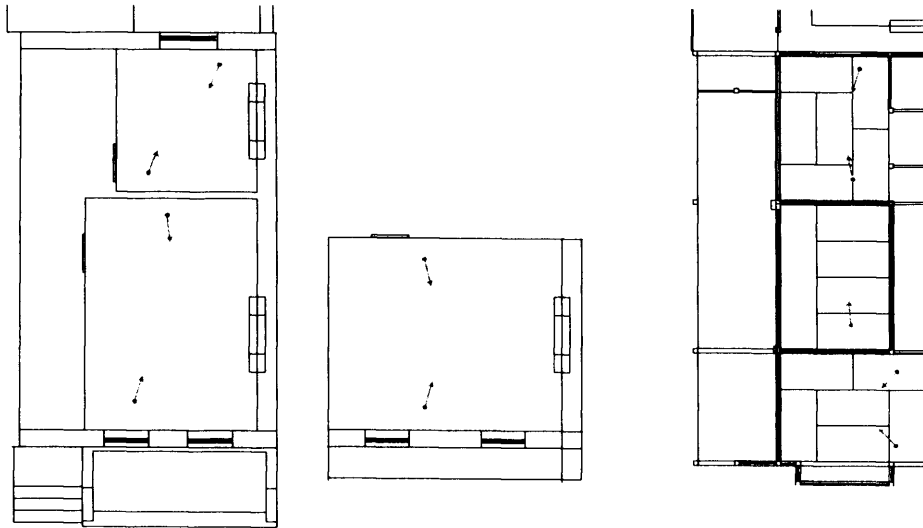
In the UK the houses can be built in any orientation, whilst in Japan there is a preference to construct with the openings, veranda, and gardens facing south. For machiya, limitations in building the residences in a dense urban area of Japan developed the two main orientations in positioning the *toriniwa*, in order to admit the daylight in the interior spaces. These are 1) *toriniwa* was placed on the east side when the site was longer in the north-south direction; 2) *toriniwa* was built on the south side when the site was longer in the east-west direction (Figure 3-2). Thus in this study for the clear sky conditions, computer simulations were conducted in these two orientations for machiya and also for Georgian house to compare the results.

FIGURE 3-2
Toriniwa was built on south side when the site was longer in the east-west direction



The possible three-dimensional luminance distribution was examined from the viewing points as indicated in the Figure 3-3. The height of the viewing points was set at 1100mm and 600mm above the floor level, respectively for the Georgian and Machiya model. The differences in the height of viewing points were adopted considering the situations sitting on a chair for the UK and sitting on the floor for Japan. The angle of view was set at 45 degrees for the all field of view.

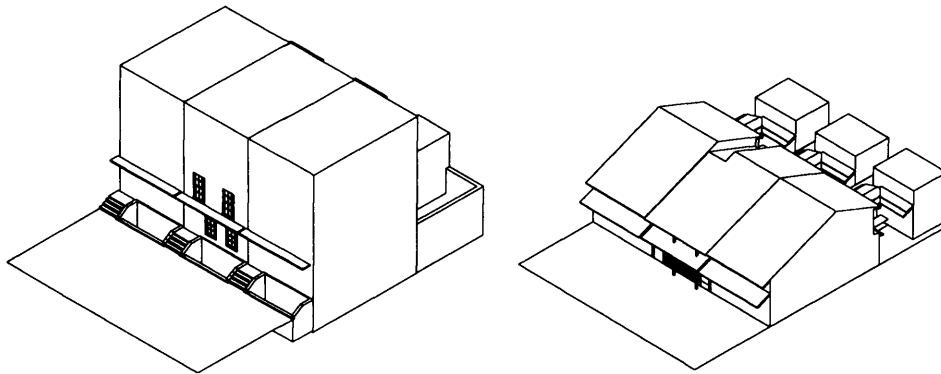
FIGURE 3-3
Diagrams indicating the view points in the Georgian house (left) and Machiya (right)



3.2 Conditions of the Computer Models

For the daylight simulations, both computer models of Georgian house and Machiya were generated in the context of inserting the main model in between two other models of the same house, for considering the exterior obstructions (Figure 3-4). However, no obstructions were placed opposite the front of the house (across the street) for the simulations. Both Georgian house and Machiya were modelled with a garden at the back. The computer models used the following assumptions for the interior finishes as indicated in Table 3-1. In the interior, furniture was not included in this daylight study. Although it may affect the overall distributions of the luminance pattern, especially for the UK model where the rooms were customarily furnished.

FIGURE 3-4
3d-computer models of Georgian and Machiya houses



In the Georgian house, wall surfaces may have been painted in dark or light colour. In this computer rendering, however, neutral colour with a reflectance of 50% was employed to calculate in the most general condition with a wooden textured door. Reflectance for the ceiling was set to be 70% assuming the white plaster ceiling, and for the floor reflectance of 22% was applied with a wooden texture. In addition, any decorative finishes that may be applied on the wall and ceiling were simplified, and the use of curtain was not considered in this simulation.

TABLE 3-1a
Room surface reflectance of
Georgian model

| | Material | Reflectance | transmit- tance |
|----------|-----------------------|-------------|--------------------|
| Ceiling | white-painted plaster | 0.7 | |
| Wall | painted plaster | 0.5 | |
| | wooden door | 0.22 | |
| Floor | wood | 0.22 | |
| Window | clear glass | 0.1 | 0.8 |
| | sash | 0.5 | |
| exterior | neighbor building | 0.1 | |
| | lawn | 0.09 | |
| | stair | 0.15 | |
| | terrace | 0.15 | |

TABLE 3-1b
Room surface reflectance of
Machiya model

| | Material | Reflectance | transmit- tance |
|----------|----------------------|-------------|--------------------|
| Ceiling | wood panel (okunoma) | 0.44 | |
| | sasara beam | 0.44 | |
| Wall | sunakabe | 0.6 | |
| | wood colum | 0.44 | |
| screens | shoji paper | 0.4 | 0.6 |
| | fusuma | 0.7 | |
| | mairato | 0.16 | |
| | koshi | 0.16 | |
| | screen frames | 0.44 | |
| Floor | tatami mats | 0.5 | |
| | wood | 0.24 | |
| | earth | 0.15 | |
| exterior | roof | 0.1 | |
| | neighbor building | 0.1 | |
| | fence | 0.2 | |

For the machiya model, the wall had reflectance of 60%, and wooden textured columns as well as ceiling materials were applied with 44% of reflectance. Three different finishes were used for the floor: tatami mats, wood flooring, and earth at the toriniwa, which had 50%, 24% and 15% reflectance respectively. Since the floor of the internal rooms were raised above the toriniwa, and partitioned with diffuse shoji screens, the interior finish for the toriniwa was also taken into account for calculation.

For the Georgian model, two vertical sash windows (single glazing) were inserted in each room at the house front on the ground floor and first floor, and one wider window was positioned at the back room on the ground level. The ceiling height for rooms on the ground floor and first floor were set at 2.8 meter and 3 meter respectively as shown in the section (Figure 3-5b).

Compared to the houses in the UK, houses in Japan have lower ceiling heights.

The ceiling height was estimated to be 2.25 meter in the parlour and under the beams of shop and dining areas in this simulation. In the shop and dining room, the ceilings consisted of several beams which support the floor of the room above, and the height from ground to underside of the first floor was modelled as 2.5 meter high (Figure 3-5a).

FIGURE 3-5a
Section of Georgian model

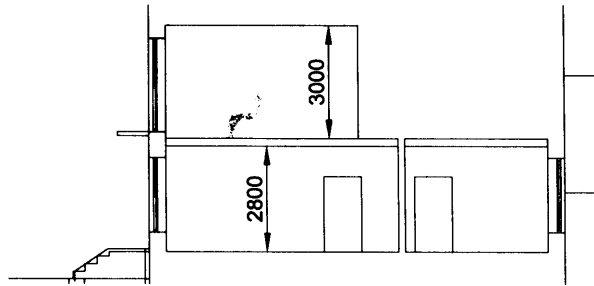
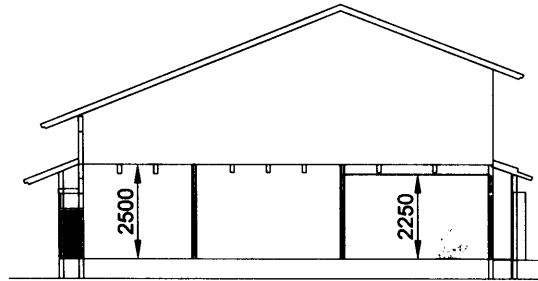


FIGURE 3-5b
Section of Machiya model



The three rooms on the ground floor of machiya were partitioned with three kinds of sliding screens such as *shoji*, *fusuma*, and *mairado* (wooden sliding panel). *Shoji* screens were placed at the sides of the rooms to partition off the *toriniwa* service/circulation space, and at the back of the room in the parlour to admit daylight through the garden. *Fusuma* and *mairado* are both opaque sliding screens, *fusuma* is usually finished with light coloured paper panel, whereas *mairado* is a wooden panel which is more sensible for using as a partition. *Mairado* partitions were placed to divide the space of shop and dining area, and also at the side of the dining area to cover the storage and staircase. Four *fusuma* panels are used to separate the dining room from the parlour. At the house front of the shop space, a lattice bay window was used, allowing a direct view out from the interior and introducing daylight inside. With three rooms to one side of the *toriniwa*, this type of Machiya created a problem in the central room when the removable panels were all closed and partitioned. The amount of daylight admitted was severely limited.

Since traditional Japanese rooms were partitioned with removable *shoji* or *fusuma* panels, they were used in several different ways. Therefore in this study, three patterns were simulated for the machiya model.

The main model was set with all four *shoji* screens closed in the parlour, and two *fusuma* open to admit daylight into the dining room.

For the other two cases, the study was set to examine the daylight distribution specifically at the back parlour space. One was simulated with all *shoji* and *fusuma* screens shut to study the light distribution in the enclosed setting. The other was to simulate with two *shoji* screens open, having more direct sunlight. In this case, the *shoji* screens on the sides are simulated as the centre screens were slide to each side and overlaid, resulting in less transmittance of light through the sides. For these simulations of parlour with clear sky were conducted for equinox, and summer solstice to compare the results. The partition between the shop and dining room was closed at all times for this computer analysis.

4 RESULTS

Results of daylight studies carried out with AGI32 software for Georgian and Machiya models are shown in the following simulations under overcast and clear skies. Three-dimensional computer renderings and its luminance distribution patterns were generated with the Radiosity calculation including the inter-reflections.

4.1 Overcast Sky

4.1.1 Georgian Model

Table 4-1 indicates the results of the average daylight factor (ADF) for the three rooms on the ground floor and first floor. Daylight distributions are shown in Figure 4-1. On the ground floor, both front and back rooms indicates less than 2% average daylight factor with a range of daylight factors less than 1% minimum to 4% maximum from the back to the front of the room. In the front room on the first floor, a range of 0.6% to 10% daylight factor was measured in the simulation, giving the best average daylight factor (over 2%) for the three simulated rooms.

TABLE 4-1
Average daylight factor of the
Georgian model

| | # pts | ave DF | max DF | min DF | min/ave | min/max |
|-----------|-------|--------|--------|--------|---------|---------|
| Gr. front | 108 | 1.5 | 3.9 | 0.6 | 0.40 | 0.15 |
| Gr. back | 49 | 1.3 | 4 | 0.1 | 0.08 | 0.03 |
| 1F front | 120 | 2.3 | 10 | 0.6 | 0.26 | 0.06 |

The rendering image and its luminance distribution for the three rooms are shown in Figure 4-2. Under the overcast sky, all the rooms generally demonstrate the same luminance patterns, where the clear glass windows are the brightest objects in the view and rest of the room surfaces are relatively small in contrast. In the parlour when looking toward the window, luminance from the windows and its immediate surrounding wall shows a big contrast in

FIGURE 4-1
Daylight factor distribution

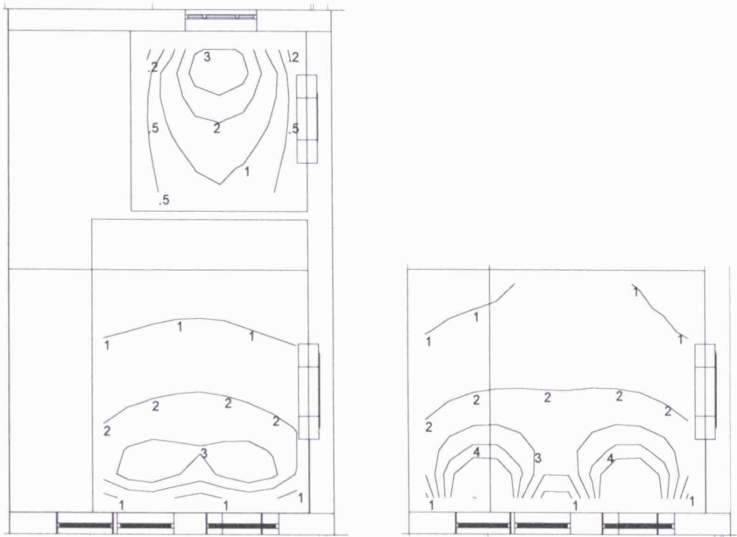


FIGURE 4-2a
Rendering and luminance
distribution in the drawing
room on the first floor

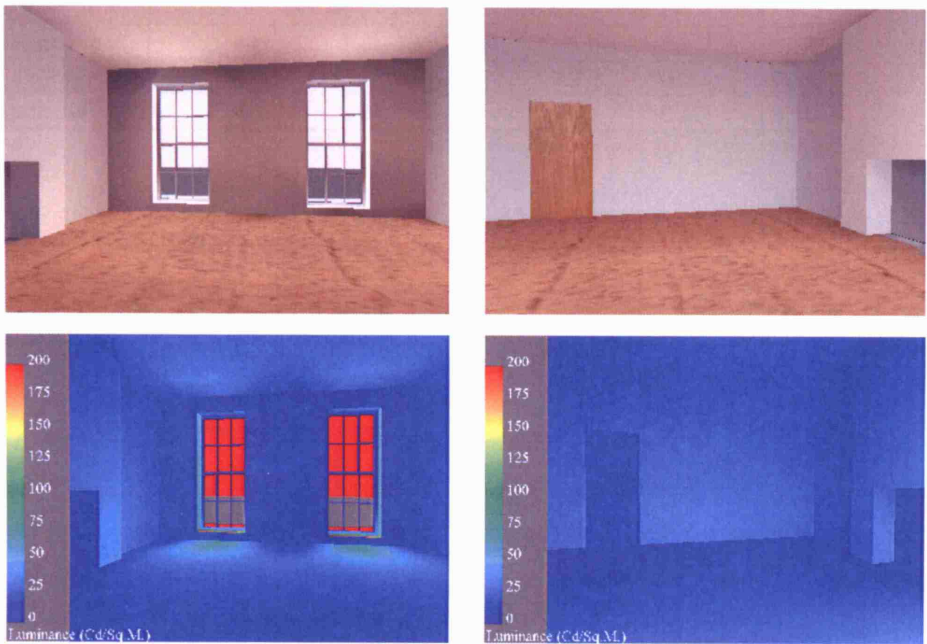
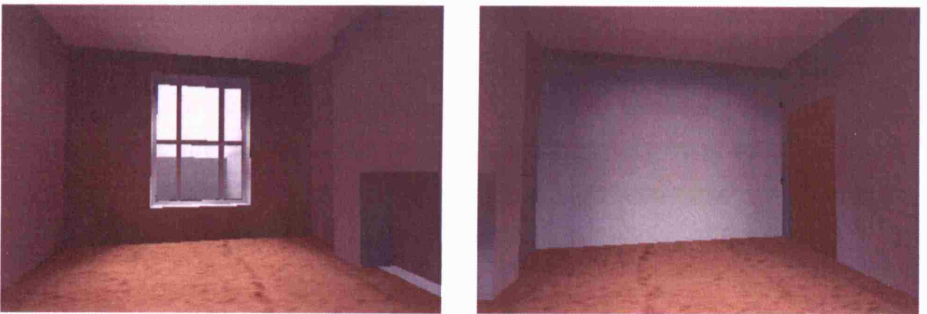


FIGURE 4-2b
Rendering of the front room
on the ground floor



FIGURE 4-2c
Rendering of the back room
on the ground floor



brightness. From the renderings it can be seen that skylight entering the rooms is producing a sort of three-dimensional modelling effect with light gradient on the surfaces.

4.1.2 Machiya Model

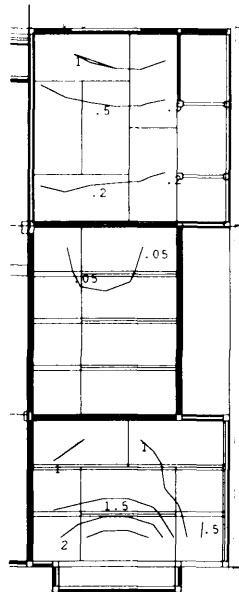
Table 4-2 indicates the results of the average daylight factors for the three rooms. All of the rooms have an average daylight factor of less than 2% with the centre dining room being especially low for the condition where it is fully partitioned from the shop (Figure 4-3).

In the parlour, the daylight factor is low with a range of 0.2% to 1.3% (average 0.5%) when all the *shoji* screens were closed.

TABLE 4-2
Average daylight factor of the
Machiya model

| | # pts | ave DF | max DF | min DF | min/ave | min/max |
|-------------|-------|--------|--------|--------|---------|---------|
| shop | 48 | 1.3 | 3.3 | 0.4 | 0.31 | 0.12 |
| dining room | 42 | 0.04 | 0.08 | 0.02 | 0.50 | 0.25 |
| parlour | 42 | 0.5 | 1.3 | 0.2 | 0.40 | 0.15 |

FIGURE 4-3
Daylight factor distribution



For the shop, as shown in Figure 4-4a the view to the lattice window show strong contrasts in skylight and wooden structures. The direct skylight reflecting off the *tatami* mats shows more variations in luminance distribution, while other room surfaces indicate less difference. As the lowest value of average daylight factor out of the three rooms indicates, inside the dining room was quite dark and it showed almost no variation in the luminance for all the room surfaces. In the parlour, luminance value of *shoji* screen ranges from about 25 to 200 cdm^{-2} , while the rest of room surfaces show gradual and small variation in the luminance by the diffused light emitted from the *shoji* screen (Figure 4-4c).

FIGURE 4-4a
Rendering inside the shop
space

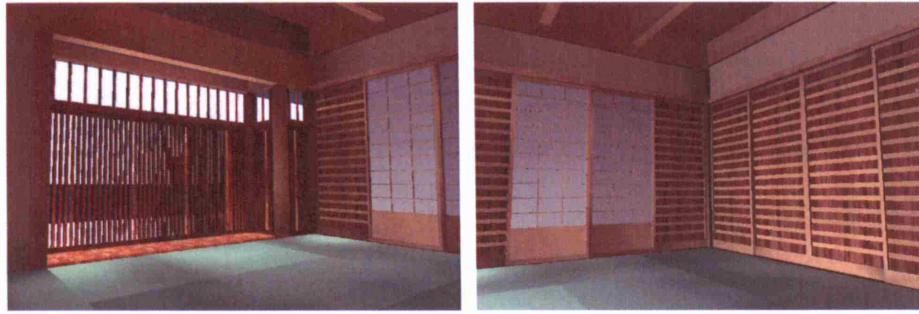
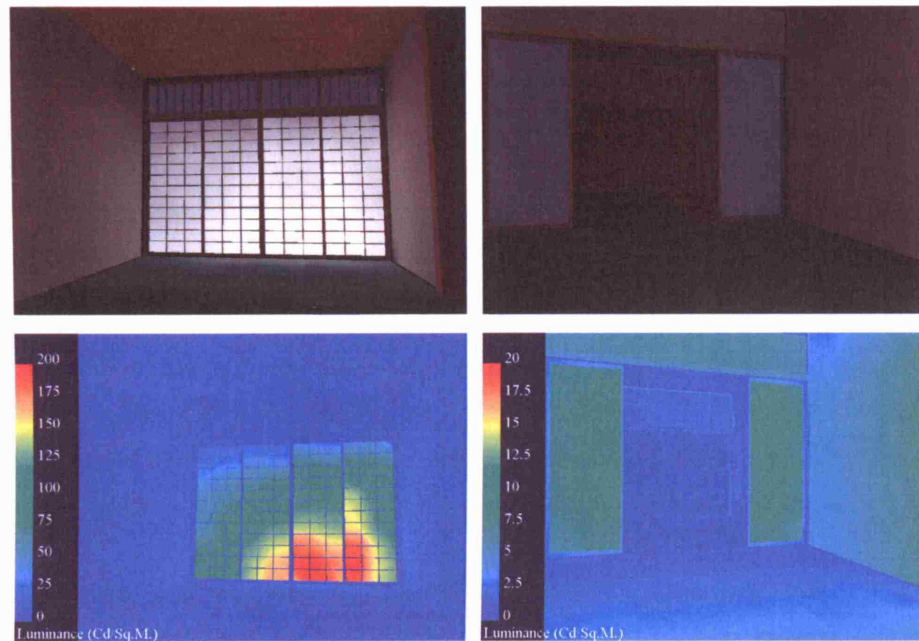


FIGURE 4-4b
Rendering of the dining area
looking toward the parlour
with two fusuma screen open



FIGURE 4-4c
Rendering and luminance
distribution in the parlour



4.2 Clear Sky

In the clear sky condition, the models of the Georgian and Machiya houses were simulated in the north-south and east-west directions, in order to examine the varieties in lighting effects when the buildings were placed in different orientation. Due to the differing weather conditions in each country the clear sky is more useful for the Japanese house, since Japanese weather may have more sunny days than the UK.

4.2.1 Georgian Model

When the Georgian model was placed in the north-south direction with the

FIGURE 4-5a
Renderings of the drawing room at 9am (above) and 12pm (below) on spring equinox

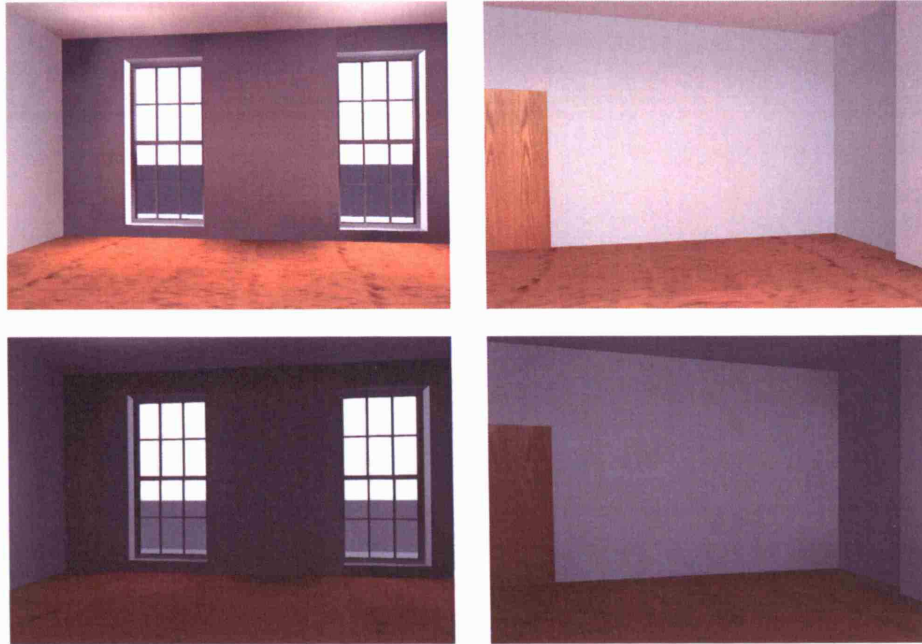


FIGURE 4-5b
Renderings of the back room at noon on summer solstice (left) and on winter solstice (right)

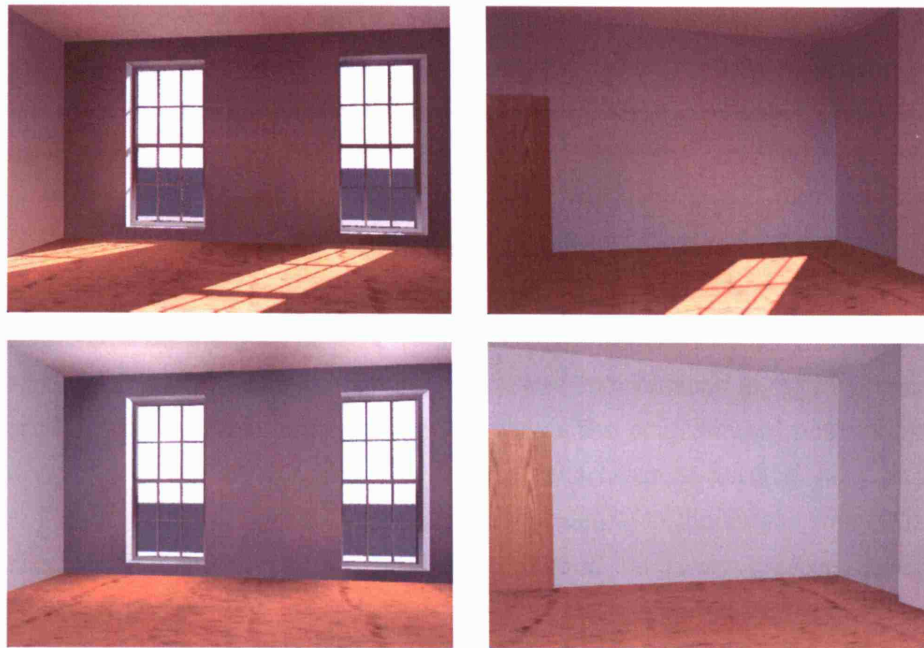


house front facing north, the two front rooms on the ground floor and first floor have no direct sunlight entering the interior throughout the year. It shows more or less the same kind of modelling effect as the overcast sky condition, however, the luminance patterns in the rooms become quite dark around noon (Figure 4-5).

When the back room on the ground floor faces south, it receives direct sunlight throughout the year. As the solar angle of altitude becomes lower in winter, sunlight entering through the window strikes the floor and wall surfaces, creating a strong luminance pattern and modelling effect for visual experience.

The other simulation was conducted with the model placed in the east-west direction with the front of the house facing east (Figure 4-6). In this orientation, the two front rooms on the ground and first floor of the Georgian house receive the direct sunlight in the early morning hours, creating a strong luminance patterns from the large sash windows. In the afternoon, the skylight entering the room produces the three-dimensional modelling effect in the room similar to the overcast sky simulation. The back room on the ground floor is the reverse condition facing west it is relatively dark in the mornings with gradually

FIGURE 4-6
Renderings of the drawing room at 9am (above) and 1:30pm (below) on spring equinox facing the east-west direction



increasing contrast in the luminance distribution as sunlight enters the room in the afternoon.

4.2.2 Machiya Model

The first simulation was conducted with the Machiya model positioned with shop front facing north and having the *toroniwa* on the east side (Figure 4-7).

FIGURE 4-7a
Rendering inside the shop at noon on spring equinox

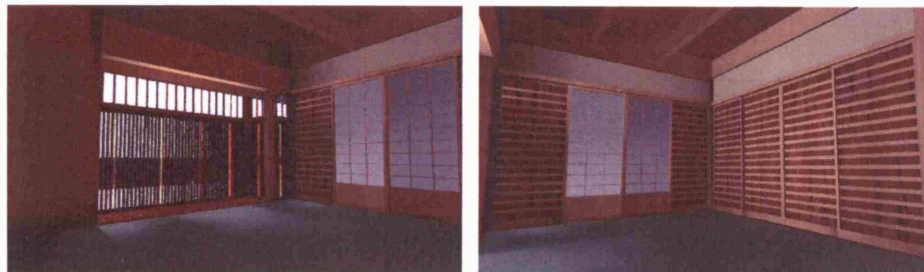
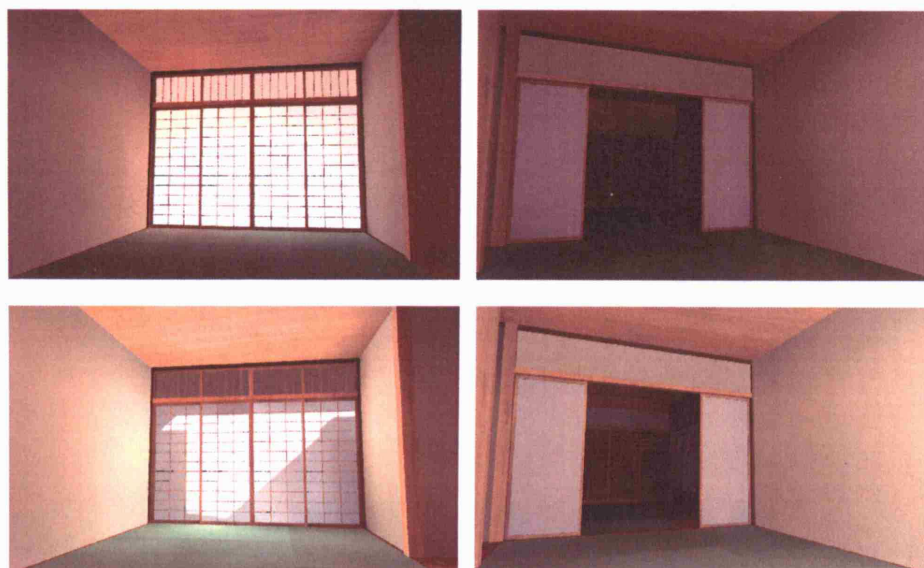


FIGURE 4-7b
Rendering of the parlour at 3pm on summer solstice (above) and on winter solstice (below)



In the shop, light filtered through the lattice opening is dispersed in the room, producing a similar visual effect of luminance distribution throughout the year. In this room it also shows a daylit environment similar to the simulation under the overcast sky.

In the south facing parlour, much of the direct sunlight from spring through summer to autumn is cut off by the broad roof overhang. In summer, the reflected light from the veranda and garden produces an even luminance distribution on the *shoji* screen. Through this big surface of *shoji* the diffused light which is introduced into the interior creates less variation in the luminance patterns. From the equinox through the winter, the *shoji* screen receives the direct sunlight creating a strong luminance patterns on its surface. As shown in Figure 4-7b, sunlight with low angle of incidence in the winter time casts shadows from the surrounding external objects and the garden creating varying contrasts and patterns on the *shoji*. However, the overall diffused light that is admitted into the room produces gradual and small variation in the luminance on the rest of the room surfaces.

In the same orientation as above, the second and third simulation was studied for the back parlour (Figure 4-8). The second simulation was modelled with all *shoji* and *fusuma* screens closed to study the brightness pattern in the enclosed setting. The third was simulated with two *shoji* screens open. When comparing these two simulations for spring equinox and summer solstice, it can be understood that direct sunlight is reflected off the veranda and *tatami* mats to the ceiling when the *shoji* is open, and luminance distribution overall in the room becomes more even when the *shoji* screen is all closed.

FIGURE 4-8
Rendering of the parlour at
1:30pm on spring equinox
with *shoji* open (above) and
closed (below)

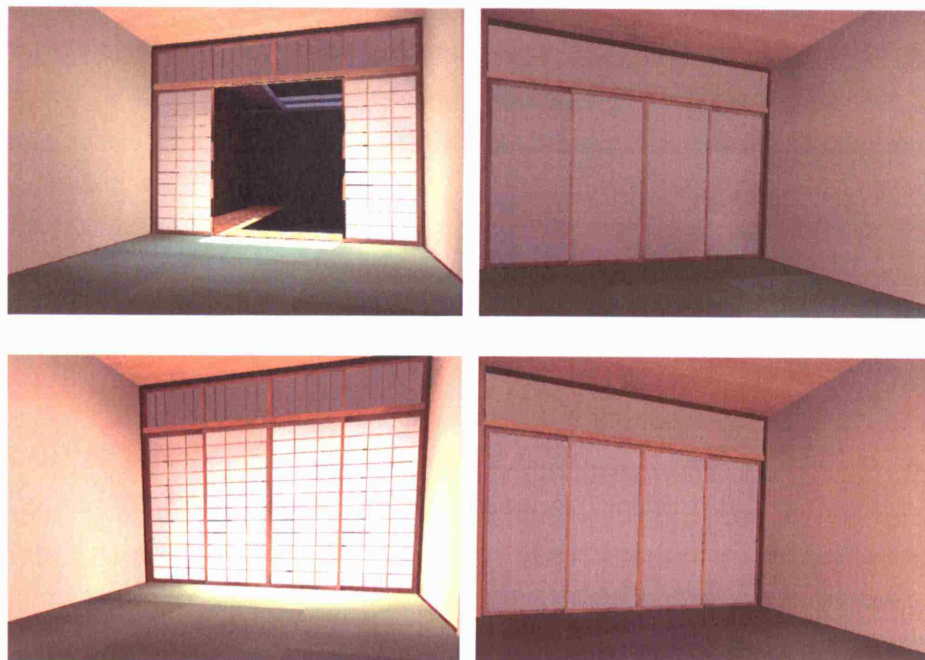
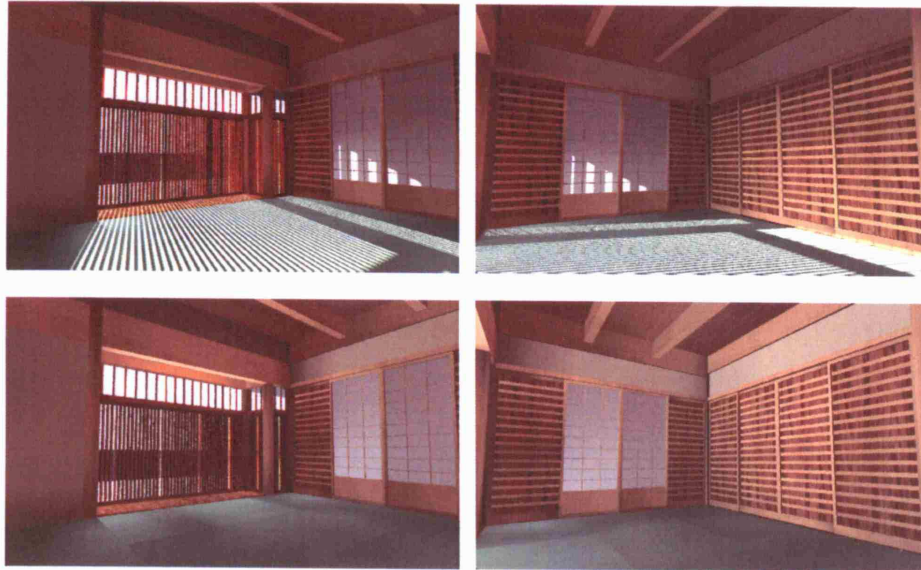


FIGURE 4-9
 Renderings of the shop at
 9am (above) and 1:30pm
 (below) on spring equinox
 facing the east-west direction



The Machiya model was orientated in the east-west direction for the fourth simulation. Having the shop front facing east, the lattice window in the shop creates strong luminance patterns in the early morning (Figure 4-9). Towards the afternoon, the shop has the same modelling effect as under the overcast sky. With the parlour facing west, it is quite dark in the morning but gets more light in the afternoon. Similar to the first simulation of the model in north-south orientation, the patterns of light and shadow are created on the shoji screen which diffuses the afternoon sunlight entering the room.

5 DAYLIGHT ANALYSIS

The results indicated above for the daylight performance of Georgian town house and Machiya show some contrasts and cultural characteristics in how they incorporated the natural light and created the brightness patterns in their rooms. In this chapter, these simulated results are analysed and compared to understand the distinctive features that have developed in different climates and cultures.

The results of the average daylight factor analysis in the Georgian and Machiya houses produce relatively low values. With the exception of the front room on the first floor of the Georgian house, all the other rooms indicate the average daylight factor is lower than 2%. This means that the appearance of the rooms would be dark and today we would find it necessary to have artificial lighting. The Machiya model generally showed a lower daylight factor than the Georgian model. This is most likely as a result of their design that uses broad overhanging eaves above the openings to avoid the direct sunlight entering into the room, to overcome their hot and humid summer. In contrast, the cool and temperate climate in the UK allows direct sunlight into a room to improve amenity which

results in a better daylight performance.

The sense of a room, however, is not only characterised by the illuminance at the task levels or the daylight factor, but also by the brightness of all the room surfaces. The impression of the brightness of the room may depend on the luminance of the ceiling, wall, floor, task plane or furniture, how they are balanced and distributed relatively in the field of view. In this study, the overall luminance pattern of the rooms has been generated under the two sky conditions.

When comparing the two models of the Georgian and Machiya houses under the overcast condition, all rooms in the Georgian model get the soft but directional skylight that creates the three-dimensional modelling effect of the rooms. But in Machiya model, the light entering through the lattice window of the shop or through the shoji screen in the parlour is redirected by the *tatami* mats which have a higher reflectance than other floor surfaces. By having more indirect light in the space, the inter-reflection of light produces a more uniform brightness pattern in the field of view. Additionally, the diffused light from the shoji screen increases the muted effect of the interior, reducing all directionality of the light that enters.

Under the clear sky condition, the Georgian and Machiya houses show a clear contrast in the control of natural light being admitted into the rooms. Whereas the incidence of direct sunlight is an essential element in housing design of the UK, in Japan the most useful source of interior daylight is the sunlight reflected from the exterior surfaces such as veranda or the ground. In the case of the Machiya, the simulated renderings show the flow of light entering into the interior predominantly going upwards rather than downwards as in the Georgian model. The light is first shaded by the large overhanging roof, and when the shoji screen is open the reflected light from the veranda and *tatami* mats mostly falls onto the ceiling. As a result it produces a more even daylit space with the overall distribution of light. Furthermore, when the *shoji* screens are all closed, any direct sunlight or indirect light would all be diffused. The illuminated white paper of *shoji* dissolves all the vector of the light incident on its surface, and produces a soft ambient that uniformly lights the space. However, the clear glazing of the Georgian window allows the direct sunlight to enter hitting the floor and/or wall surfaces, creating a strong contrast in luminance patterns. In the Georgian house the rooms are not uniformly lit, but it is rather like having a strong spotlight. This spot of light sometimes becomes a source of glare, which may be reduced with a shading device. But overall it tends to create more dramatic modelling effect in a room.

In the UK the buildings can be orientated in any direction with no particular preference. In Japan there is a strong cultural preference for buildings to face south. The results of the computer simulations for two different orientations of the two buildings may suggest that the use of overhanging eave and shoji screen with less transmittance of light may produce in people a preference for a south facing orientation so that more daylight can enter in the room. This will create more bright patterns of light on the shoji screens.

In the UK, in contrast, the orientation of the house was considered less important having overcast skies predominantly throughout the year. But having a view out and receiving the direct skylight through the clear glazing was more significant in their building concept.

6 DISCUSSION

Overall from the daylight analysis on both overcast and clear sky conditions, it is found that the clear glazing employed in Georgian house produces more contrasts in luminance patterns with directional light creating three-dimensional modelling effects in the room. By comparison, a more indirect and diffused light is introduced into the Machiya due to the overhanging eaves, reflective *tatami mats* and *shoji* screen, which results in having a muted effect in a room and a more uniform brightness pattern. In this chapter these findings are compared to the present artificial lighting environment in the UK and Japan, to see if there is any link to the visual experience in the daylit environment of their traditional town houses.

The simulation and analysis of Georgian and Machiya houses demonstrates a variety of developments in architectural details that indicate how different countries embraced the use of natural light before the arrival of electric lighting. The only artificial light sources used in the UK and Japan in the 18th century were oil lamps and candles, and how they customised these light sources reflected their different living styles.

Typically in the UK covering the flame with a small glass chimney, the lamps were often suspended from the ceiling, mounted on the wall, or used as table or floor lamps illuminating the task level, whereas in Japan, lanterns were shielded with paper devices predominantly placed on the floor, lighting the lower part of the room.

In the contemporary domestic environment, in the UK a lot of people still utilize the incandescent lamps for lighting their homes, while Japan leads the world in the use of fluorescent lamps in homes. Today it is said that about 80% of Japanese households use the fluorescent lamp for illuminating their rooms¹⁰.

In Europe, fluorescent lamps are associated with a cool white light used for the office or hospital environment and is therefore not considered a suitable source for a domestic environment. The incandescent lamps are preferred in houses because they give a warm light that is reminiscent of a flame, which creates a cosy atmosphere.

In general, it is said that the colour temperature preferred in domestic lighting for Japan is about 4000K to 6700K (cool - cold white), while for Europe it would be about 2800K to 3000K (warm white). This characteristic can be related to the study of Park (2001) that found Americans perceived their skin tone as more attractive under 3000K, while Koreans perceived their skin tone better under 5000K. There may be a physiological and/or psychological variance between Western countries favouring the warm light and the cooler light preferred by Orientals. In addition, current lighting practice suggest that the warm coloured sources are preferred at low illuminance, whereas cool colours are perceived to be better at high illuminance. As a cool white fluorescent lamp appears gloomy at low illuminance, Japanese residential lighting has a tendency to be brighter than the Europeans to compensate.

When looking at the history of the artificial lighting development from the oil lamp/candle to the light bulb, the design, size, and location of the luminaires did not change much for domestic lighting in Europe¹¹. Currently many living room spaces are designed with the same lighting scheme as the 18th century using pendant lights, wall sconces, table lamps or floor lamps with the electric lamps (Figure 6-1). Several luminaires are used to illuminate a room not just one lamp as in a Japanese house. Multiple luminaires create a variety of brightness patterns in a room.

To the contrary, the artificial lighting in Japan shows discontinuous development compared to the Europe. Before the country's modernization in the Meiji period, most of the luminaires using oil lamps or candles were placed on the floor of a room. After the Meiji Restoration, however, when paraffin lamps and subsequently gas lamps were imported, these luminaires were not only placed at the floor or task levels, but also were hung from the ceilings. Since these imported light sources were brighter than the traditional oil lamps, the reason they were installed in the upper part of the room may have been to avoid glare. As a result, the introduction of this innovation in lighting brought a big change in Japanese living styles and visual experiences.

From this time until present, even after the advent of incandescent lamps, in many Japanese houses the dining, living room and bedroom spaces

10 - Inui, M. *Yoru wa kurakutewa ikenai* (Is it wrong to have a dark night?). (Asahi-shinbunsha, 1998) p145

11 - *ibid.* p150

FIGURE 6-1
Pendant, wall sconces, and
table lamps with incandescent
sources typically used in the
UK



FIGURE 6-2
Ceiling mounted fluorescent
luminaires used in traditional
Japanese room and modern
living room



have become predominantly lit by ceiling mounted luminaires (Figure 6-2). Furthermore, following the end of World War II, the incandescent lamps were replaced by the brighter and whiter light from fluorescent lamps, which had rapidly spread across Japan to illuminate both home and work environments. Even today, the domestic lighting environment in Japan is typified by the use of single fluorescent luminaires mounted at the centre of ceiling in a room, illuminating the whole space uniformly and bright.

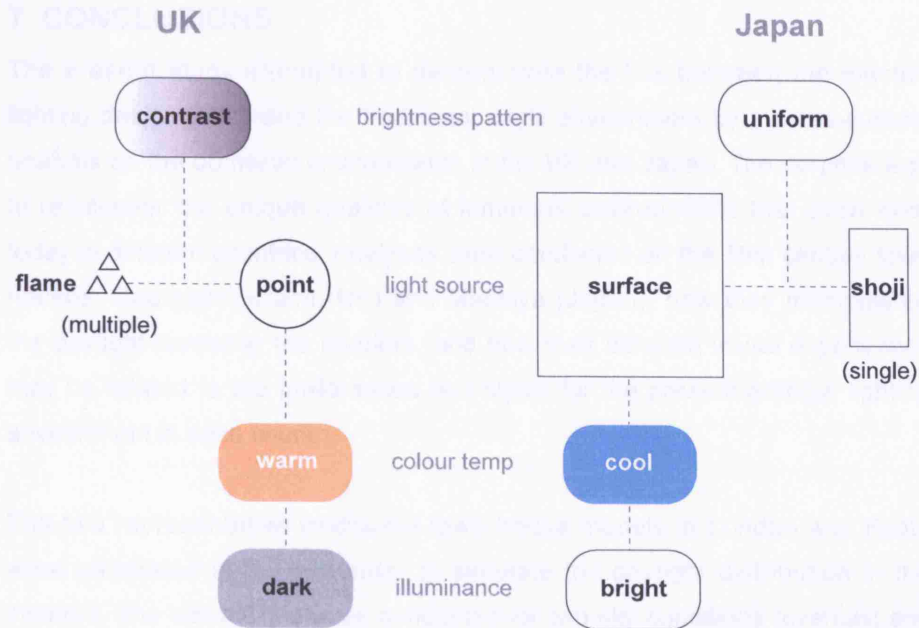
These differences in the use of the diverse types of light sources, luminaires and lighting designs in a contemporary living space in the UK and Japan show some kind of a link to the manipulation of natural light in their traditional architectures. Figure 6-3 illustrates a diagram deduced from this study for the possible relationships between the lighting elements and their effects.

Where the clear glass windows in the UK houses were designed to admit directional light, creating contrasts in luminance patterns and three-dimensional modelling effect in a room, the small point source of incandescent luminaires also produce defined shadows and strong gradients of brightness.

On the contrary, the big white surface of *shoji* screens diffuses all the light that enters and having more inter-reflections of light through the interior surfaces, it produces a more uniform brightness on room surfaces. These effects are also similar to the lighting effect created by a typical fluorescent ceiling luminaire (see Section 2.3), illuminating the overall room with diffused light and generating soft shadows and fewer brightness patterns with low contrast.

FIGURE 6-3

A digram indicating the relationships between the lighting elements and their effects found in the domestic environments of the UK and Japan



Additionally, as Küller et al. pointed out in their cross-cultural study in work environments, participants in the UK showed a seasonal difference in psychological mood, which could be ascribed to variations in length of a day over the year. Having many overcast days and short hours of winter daylight, people in the UK may have associated the warm source of incandescent lamps with a flame light. While in Japan having less variation in the length of a day from the summer to winter and generally having clear skies during the winter, it may have made a stronger impression on the daylit white *shoji* screens as a source of light, thus preferring more cool white fluorescent lamps. Overall, not only the luminance patterns perceived within the daylit built environments, but even the light source itself have some kind of relation to the psychological impressions on the different visual experiences in the two countries.

Fundamentally, current lighting analysis techniques mostly utilize single lighting values such as luminance and illuminance, which do not completely describe the quality and quantity of a particular lighting environment. Not only the adaptation state of the eye, but also the psychological aspects (personal experience, expectations, and emotion) of a person may affect the impressions of one's visual perception. In addition, for the daylight analysis it is more appropriate to study the temporal and spatial variability as dynamic phenomena instead of taking a mere amount of figure simulated for a certain time.

7 CONCLUSIONS

The present study attempted to demonstrate the link between the electric lighting design today and the traditional daylit environment by a cross-cultural analysis on the domestic environments in the UK and Japan. The purpose was to rediscover the unique qualities of luminous environments that even exist today in different countries. Analyses were conducted on the 18th century town houses, Georgian terrace (UK) and Machiya (Japan), how they manipulated the daylight revealing the interiors, and how their different visual experiences may be related to the preferences and styles for the present artificial lighting environment in each country.

The two representative traditional town house models in London and Kyoto were generated in the computer to simulate the daylight distribution in the interiors. The simulations were conducted for two sky conditions (overcast and clear skies) and two orientations (north-south and east-west directions) of the buildings. Computer renderings and luminance distributions were produced for the three rooms for both Georgian and Machiya houses at different times of the day for spring equinox, summer and winter solstice. The model calculations were conducted within the limitations of the software package, which generalises the modelled surfaces. Also, no furniture was included in the computer models.

When the results were analysed, they suggested the overall distinctive characteristics of the daylit environments for the two models were influenced by their different climate and cultural backgrounds.

- In Georgian interiors generally, the brightness patterns have a higher contrast producing a good three-dimensional modelling effect. The clear glass windows admit direct daylight and sunlight. The value attached to daylight is shown by the size of windows used and the relatively high average daylight factor found in the drawing room. Capturing as much daylight from overcast skies means that when sunlight enters the room brightness patterns with high contrasts are produced enlivening the space.
- Inside Machiya the brightness patterns produced are more uniform and muted, with the shoji screens diffusing the light that enters. This reflects the climatic conditions in summer avoiding the direct sunlight entering the interior, by the use of the overhanging eaves above the openings. This affects the average daylight factors which are lower than the Georgian house.
- ◆ From this it is found that the climatic conditions have greatly affected in the development of the traditional architectures and how they incorporated the natural light.

These analyses on the daylight studies were discussed and compared to the present artificial lighting environments and similarities were found.

- The artificial light back in the 18th century in the UK was typically an oil lamp with a small glass chimney covering the flame. These lamps were often suspended from the ceiling, mounted on the wall, or used as table/floor lamps illuminating the task level. Today, similar types of luminaires are still used with incandescent lamps, for many domestic lighting. These luminaires create defined shadows and strong contrasts of brightness, which is similar to the lighting effect produced in the daylight environment.
- In Japan, daylight muted by a shoji screens has clearly influenced the design of lanterns, which were covered with a paper shielding device. Traditionally these lanterns were placed on the floor lighting the lower part of the room. However, after importing brighter light sources the luminaires were typically placed in the centre of the room hung from the ceiling. A typical fluorescent ceiling luminaire used in Japan today, illuminates the overall room. The diffused light emitted from the luminaire create the same lighting effect as the shoji screen, generating soft shadows and fewer brightness patterns with low contrast.
- ◆ In order to mimic the variety of brightness patterns created by daylight, multiple incandescent luminaires were used in the domestic lighting environment in the UK, producing a lower overall illuminance. By contrast the Japanese utilized one ceiling fluorescent luminaire which produced a higher overall illuminance.

Moreover, it was estimated that different preferences in lamp types and their colour temperature may be related to the diversities in climate and cultural perception of the different countries.

- In the UK people may have associated the warm source of incandescent lamps with the light from a flame, due to there being more overcast days and shorter winter days.
- As a source of light the white shoji screens have had a strong influence on the Japanese psyche. Thus a preference for more cool white fluorescent lamps.
- ◆ This suggest that my premiss that the development of electric lighting environment has been influenced by the daylighting.

Altogether, the study supported the hypothesis that there are similarities in the visual experience found in daylight and artificial lighting environments of each

country. Also it proved that our experience of light is built on the environments that we are familiar with.

This paper highlights the origin of the luminous environments in houses of the UK and Japan. The way both countries manipulated the daylight in traditional architectures and how the preferences for the domestic lighting environment today are governed by the cultural elements and the visual perceptions we grow up with.

Further researches are suggested in determining the lighting preferences by questionnaire and measurement of the real luminous environments (daylit and electric lighting conditions) in each of the UK and Japanese houses. In addition, since this study was limited to analyse the traditional daylit and electric lighting environments separately, the supplementary study can be conducted to examine the luminous environments produced with both daylight and electric lighting conditions at different times of the year. Investigations in a more countries with different climatic and cultural backgrounds may certainly be useful for bringing a more different perspective in the built environments created around the world, and also enhance the international understandings.

Historically, humans have developed many architectural designs to reveal the inside of buildings using daylight with various features depending on the climatic and cultural contexts. However, since the advent of electric lamps there has been a concern that there is a danger that anonymous lighting environments can be now produced anywhere in the world.

Having already realized the negative impacts of daylight-free environments for both global warming and human well-being, the trend today is more and more to integrate daylight with artificial lighting.

The implication of this move to closer integration will hopefully mean an increased trend to create a new visual experience.

At the time of expanding globalization with the lighting designers working across the countries, this research provides a pointer for how the ingress of natural light in the traditional built environment of two different cultures may have affected the appreciation in choosing and arranging the artificial light in each country.

It is essential for international designers to understand the unique qualities of both daylight and artificial created in different places, in order to avoid producing anonymous designs. Also, this cross-cultural study would be useful information for the lighting industries advancing the new technologies and light sources to consider what kind of lighting quality is really required for the further development.

With developing light sources such as LED and OLED it is not only important that their performance surpasses that of conventional light sources, but also that

they are harmonised with the built environment where natural light is the primary source of light.

By looking at the daylight and the artificial lighting environments together with the quality of the light and their links, this study offers a basic knowledge for developing the advanced luminous environments in the 21st century.

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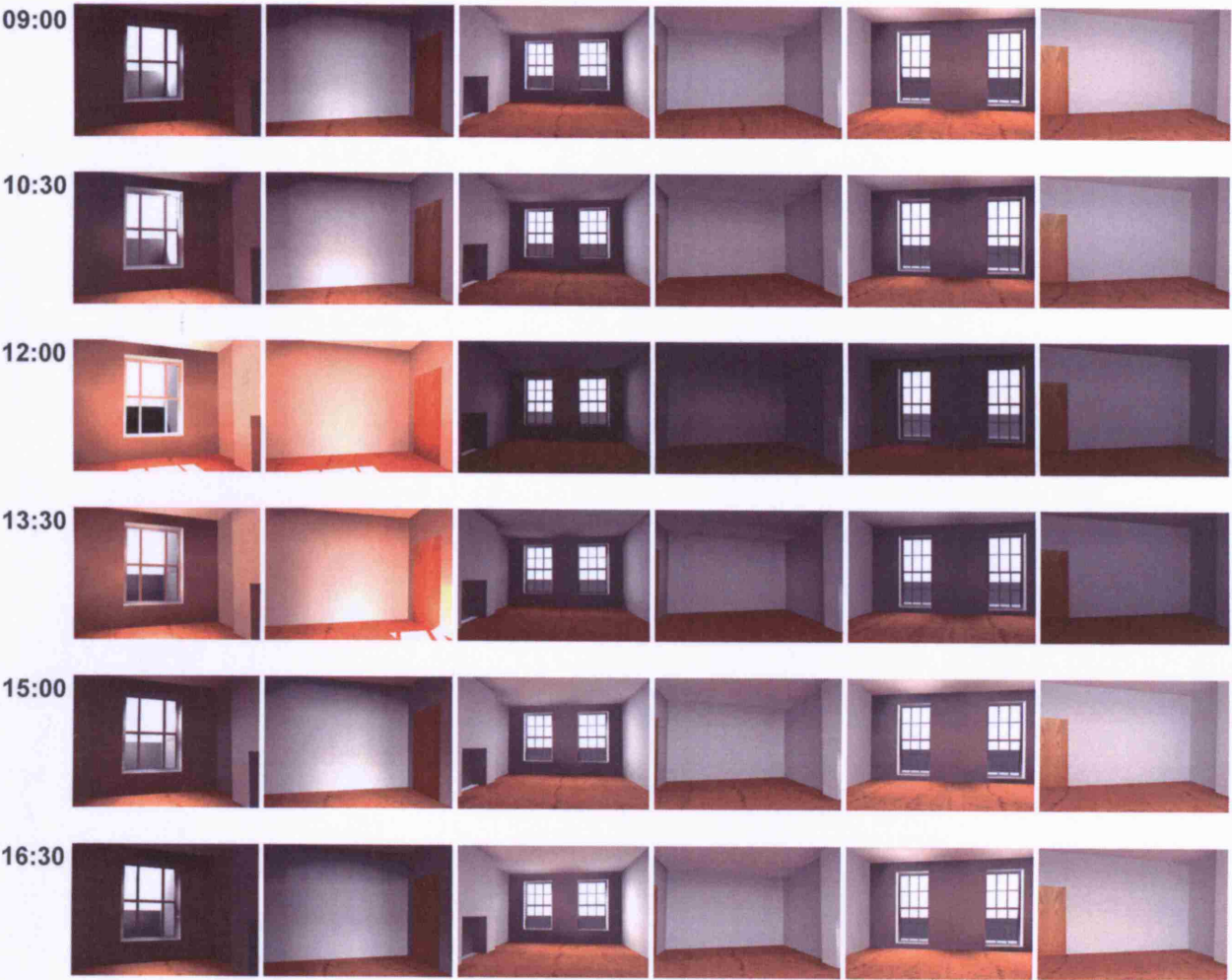
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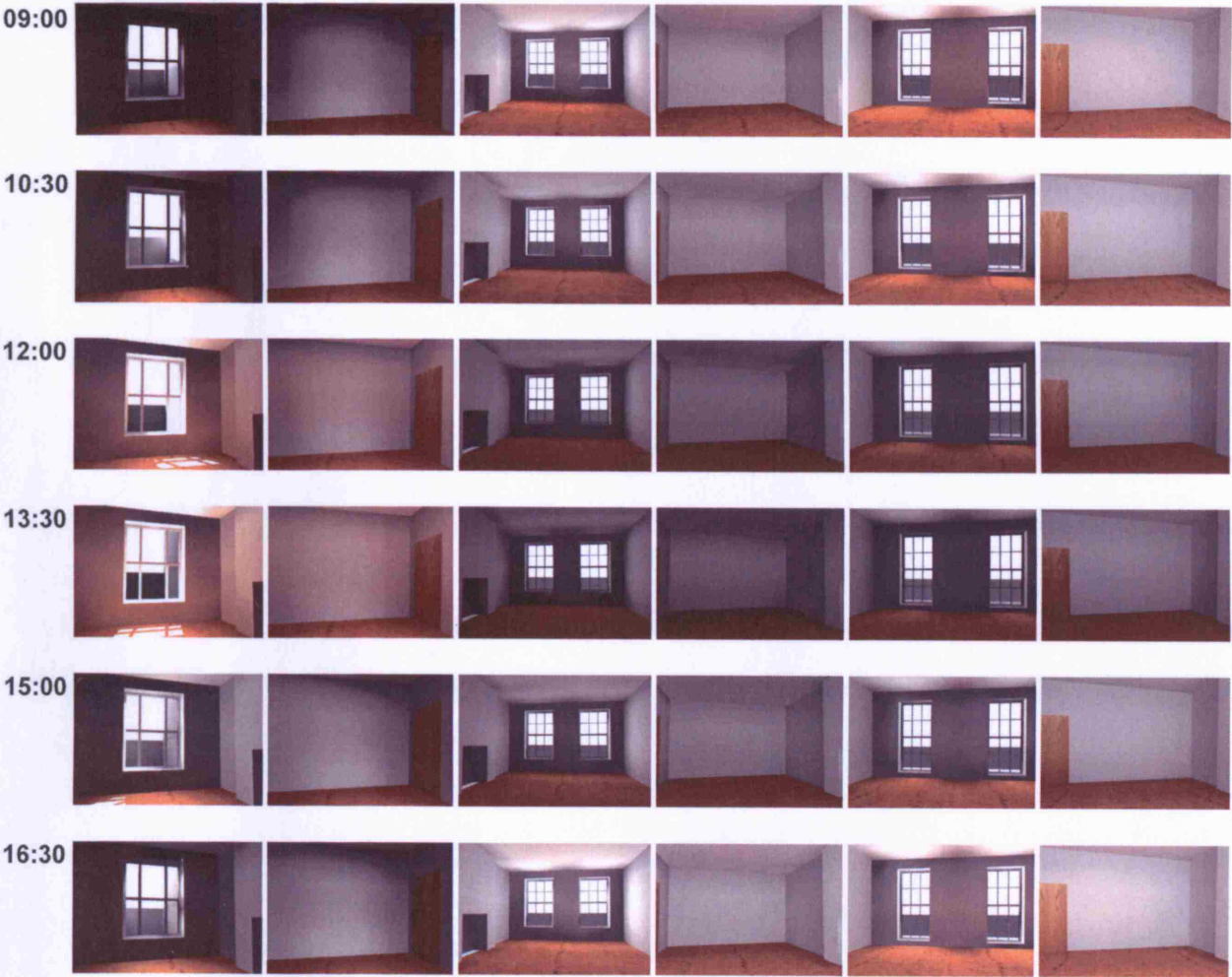
APPENDIX

Georgian house - clear sky 01 - spring



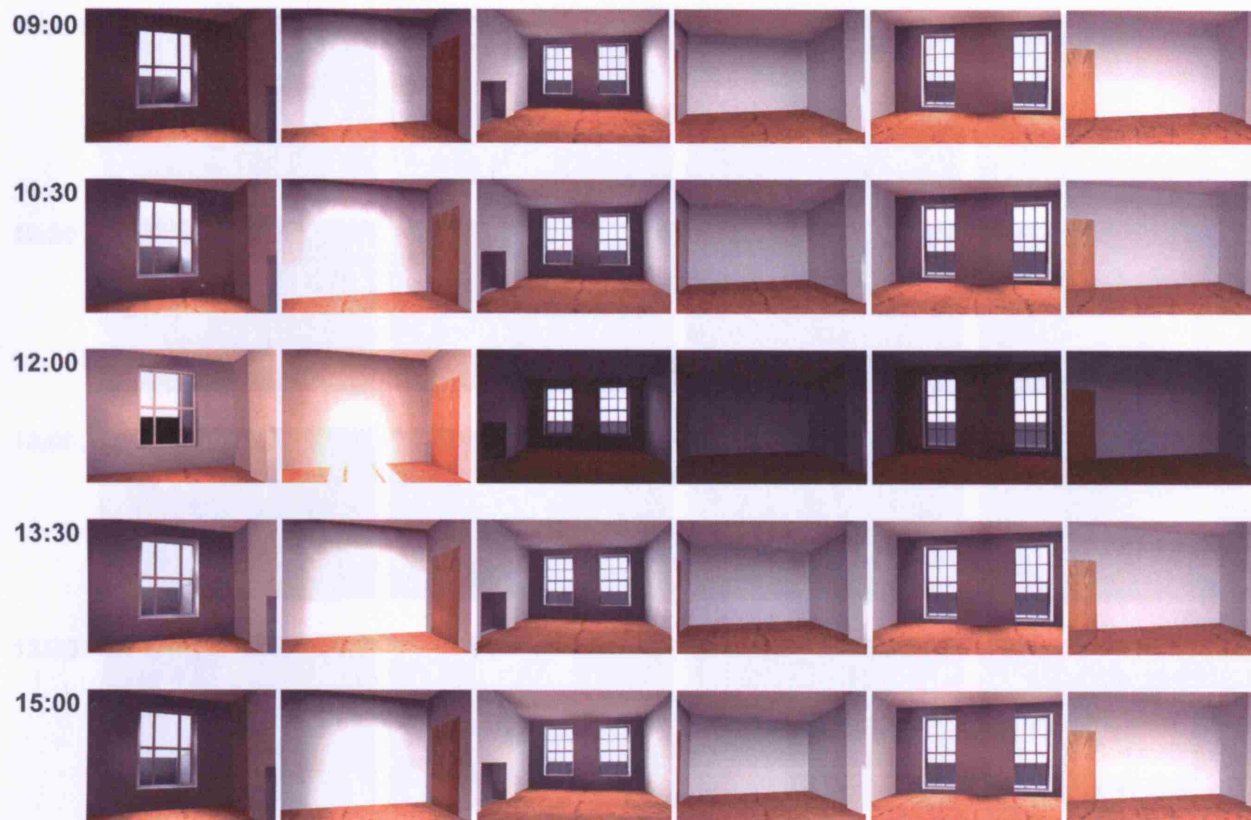
APPENDIX

Georgian house - clear sky 01 - summer



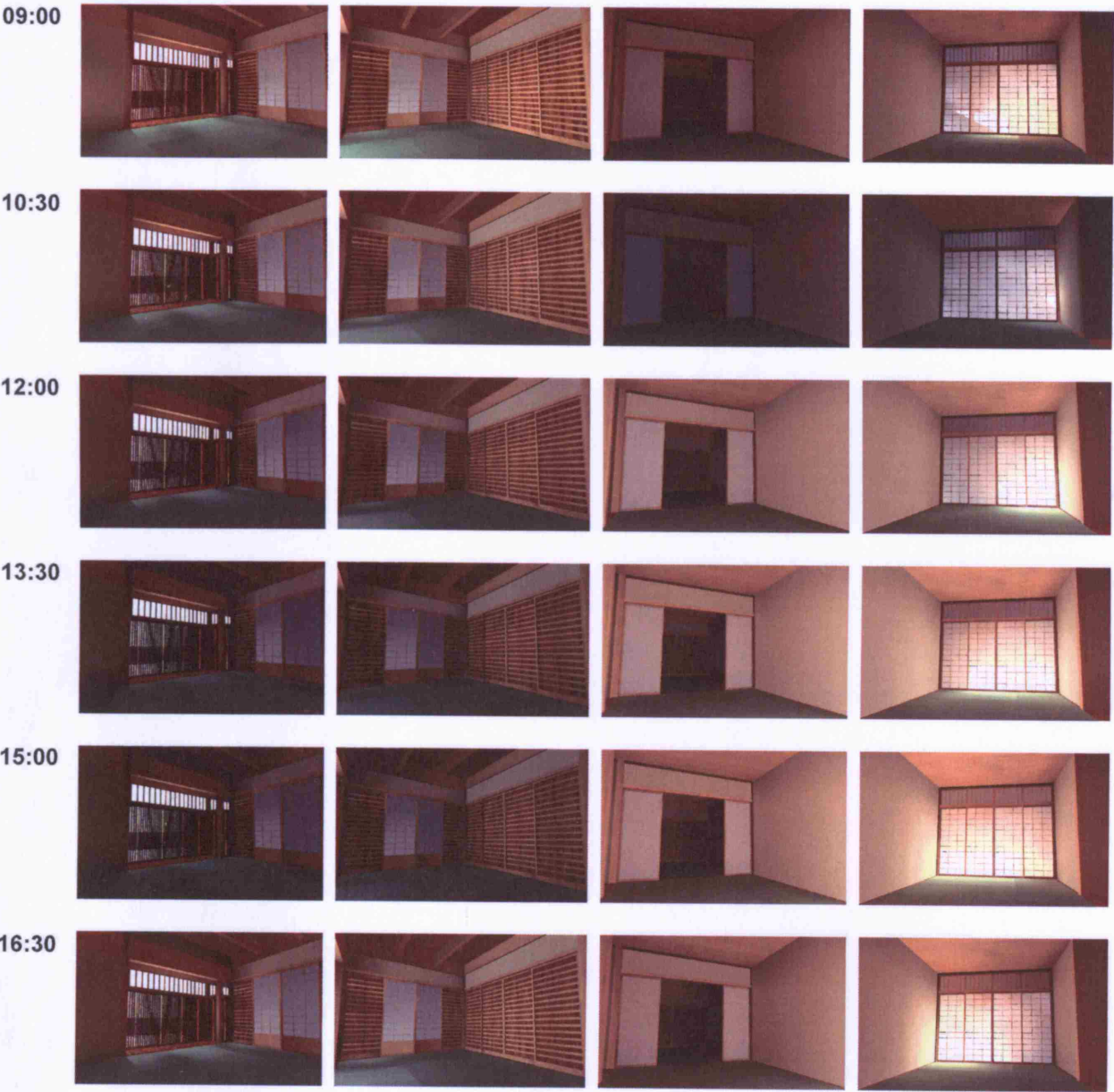
APPENDIX

Georgian house - clear sky 01 - winter



APPENDIX

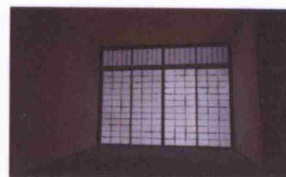
Machiya - clear sky 01 - spring



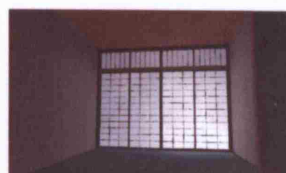
APPENDIX

Machiya - clear sky 01 - summer

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10:30



12:00



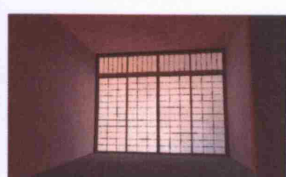
13:30



15:00



16:30



APPENDIX

Machiya - clear sky 01 - winter

